Intelligence, Reconnaissance and Surveillance Science and Technology

Expeditionary Warfare and Combating Terrorism

Large Tactical Sensor Networks Program

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
MAY 2007		**00-00-2007 to 00-00-2007**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Large Tactical Sensor Networks Program	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Mitre Corporation,202 Burlington Road,Bedford,MA,01730-1420**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
2007 Netted Sensors Community Workshop, 3-4 May, McLean, VA

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**24**	

Large Tactical Sensor Networks

Program Objective

Enable Tactical Persistent ISR, Relevant to the War on Terror

- **Sensor Models**
  - Translate threats to detectable features
  - Translate a specific sensor to its ability to detect relevant features
- **Smart Sensors**
  - Processing at the sensor node to translate raw data to useful information
  - Indexed distributed data structure that enables sensors nodes to have “context”
- **Service Oriented Sensor Network**
  - Hardware and software that enable current or planned sensors to transition to a netcentric environment
  - Enable distributed control of persistent ISR assets

Relevant raw data to useful information for tactical situational understanding

Large Tactical Sensor Networks

- **Fusion**
  - Aggregation algorithms, rules & formulas, pattern definition and analysis, space/time correlation to events
  - Match analytic resources to volume of persistent ISR assets
- **Automated Tactical Platform & Sensor Planning and Management**
  - Algorithms to control and direct persistent ISR assets
  - Aligned set of multi-INT collection plans
  - Software enabling dynamic sensor management
- **Human to Sensor Field Interface**
  - Alert quick reaction forces
  - Interface between the operator and knowledge repository
- **Local Tactical Net & DCGS Integration**
  - Smart agents that manage bi-directional flow of data, useful information and knowledge between DCGS and the tactical user

Relevant raw data to useful information for tactical situational understanding

Large Tactical Sensor Networks
Product Integration

Relevant Research and Results . . .Yesterday, Today, and Tomorrow

IMINT

SIGINT

All Source/MASINT

HUMINT

LTSN Services

Enabling Sensor Swarms

You're closer, go there, I'll go here.

Entity Tracking

Where is Joe?

Uh oh – someone's over there.

Interface to Warfighter

EARPIECE
THROAT MICROPHONE
SINCGARS
WEARABLE COMPUTER/GPS
BATTERY PACK

Warfighter Alerts

Determine TTPs

Distributed Knowledge and Knowledge Needs

Mission Aware Sensor Field

Semantic Web

Division

MEU

Battalion

Helicopter

Logistic

Logistics

I just saw Amad.

Images to Network Understanding

(Suspected Bad Guy) (Bad Guy)

(Power Plant)

(Works At)

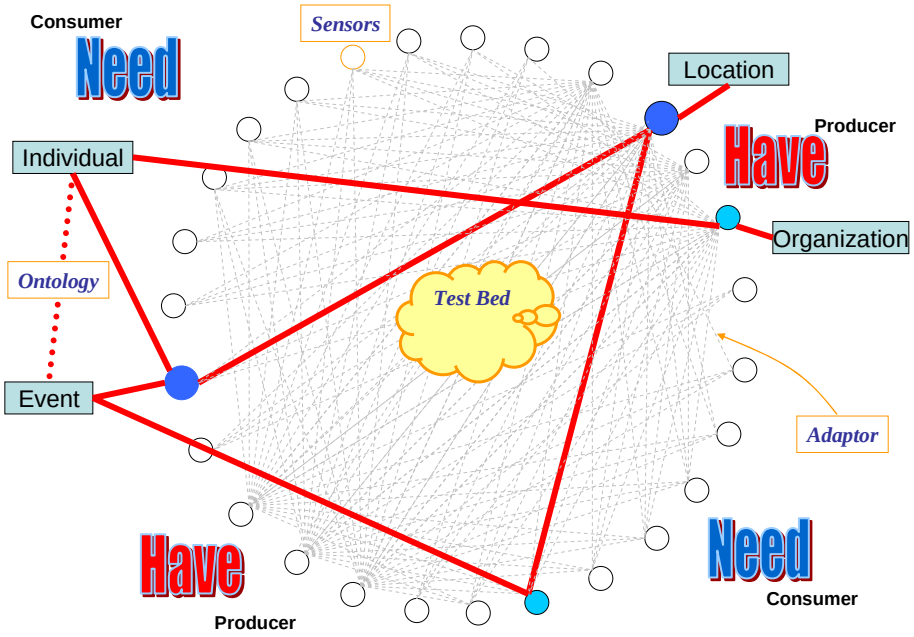
COMINT to Network Understanding

Window to DCGS

SOA

Semantic Web

- Create an ontology which provides a standard representation that users can query for meaningful information.
- Create a set of standards, tools and test bed that will demonstrate how a tactical ontology and semantic-based sensor networking can dramatically improve the effectiveness of intelligence resources



Statistically Determine TTPs

- Create Statistical-based modeling of features to sensor modalities
- **Choice of Features for Reduction**
  - Determination of the importance of each feature required
  - Use metrics that compare the effect that reduced subsets of features have versus using the larger datasets
- **Placement of Sensors**
  - Model the capability of each defined sensor to acquire detectable features and characteristics
  - Optimal placement of sensors, even with full information on existing and expected threat
  - Forecast and visibility models for each sensor
  - Placement algorithm for sensors. Sensor type database with range profiles, sensitivity, uncertainty will be utilized

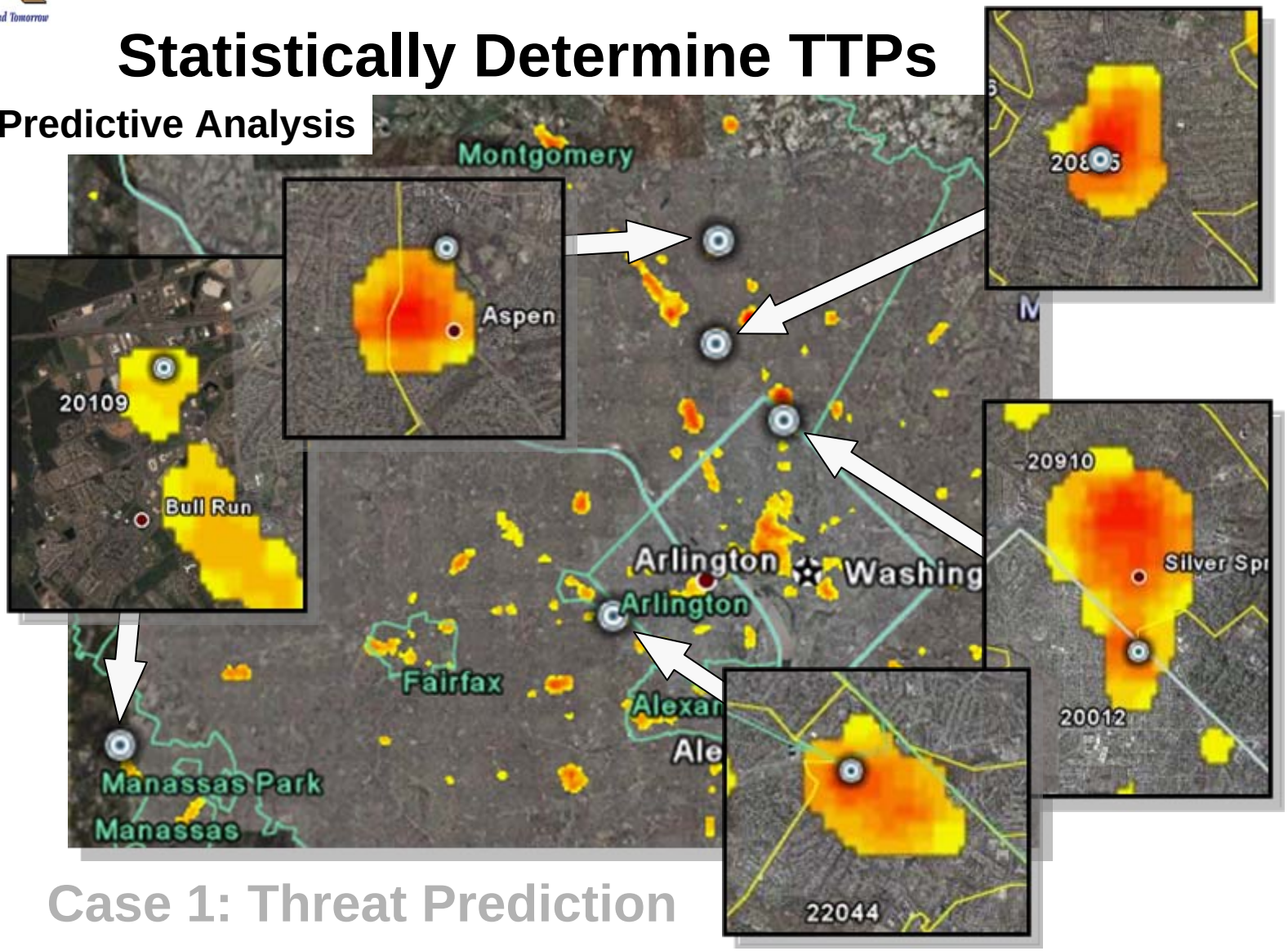
Statistically Determine TTPs

- Innovative geospatial analysis and asymmetric-threat modeling techniques for urban environments
  - Foundation of technique is associations made between event data, sensor data, and contextual information sources
  - Technique excels at indicating:
    - Greatest level of threat for GWOT mission
    - Level of threat expected at each point along a travel path
    - Greatest likelihood collection areas for observing a target
  - Technique reduces the search area required and maximizes the placement of resources

ONR
Relevant Research and Results . . . Yesterday, Today, and Tomorrow

Statistically Determine TTPs

Geospatial Predictive Analysis

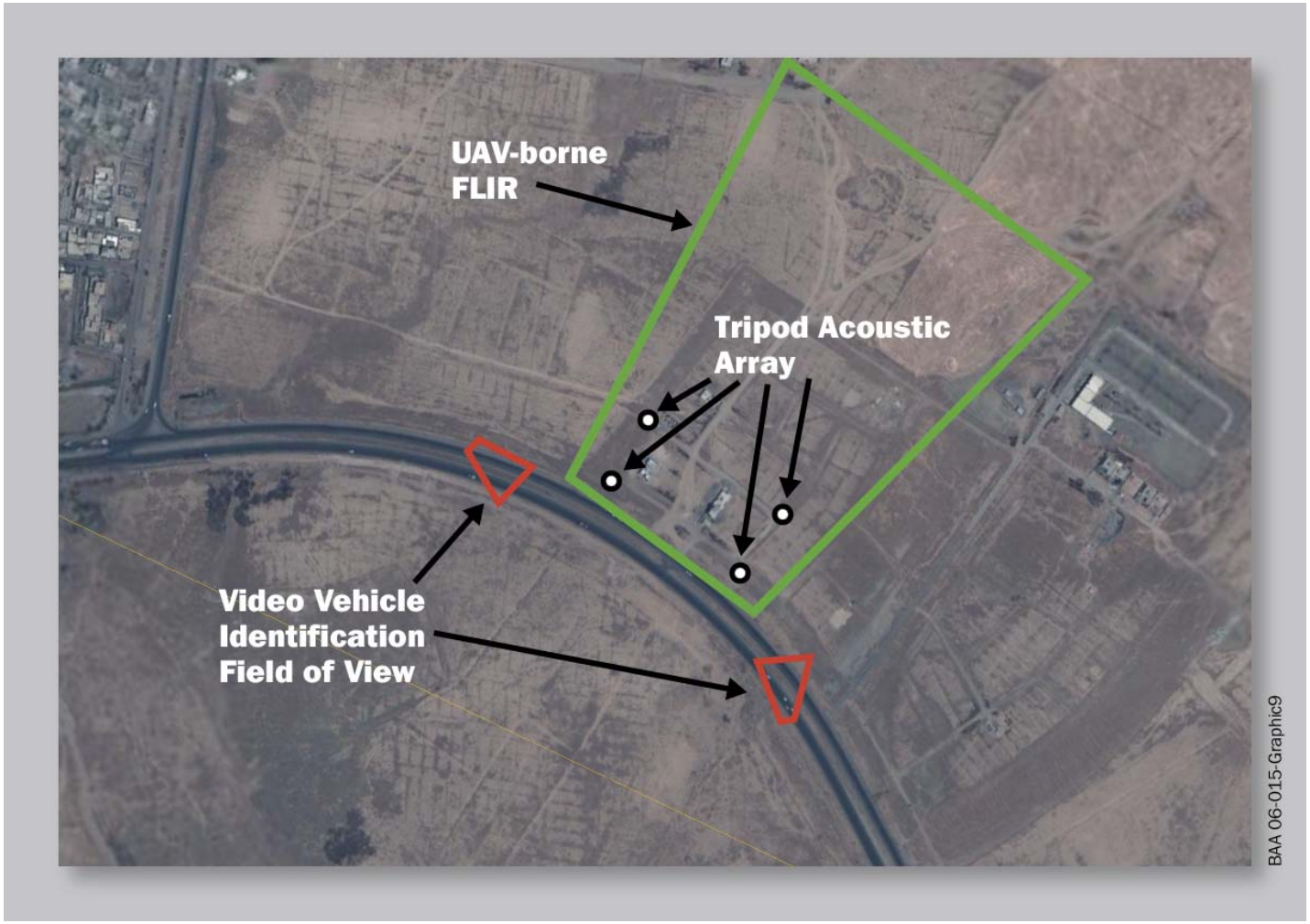


Attack Location

Highest Likelihood Areas

Case 1: Threat Prediction

Statistically Determine TTPs



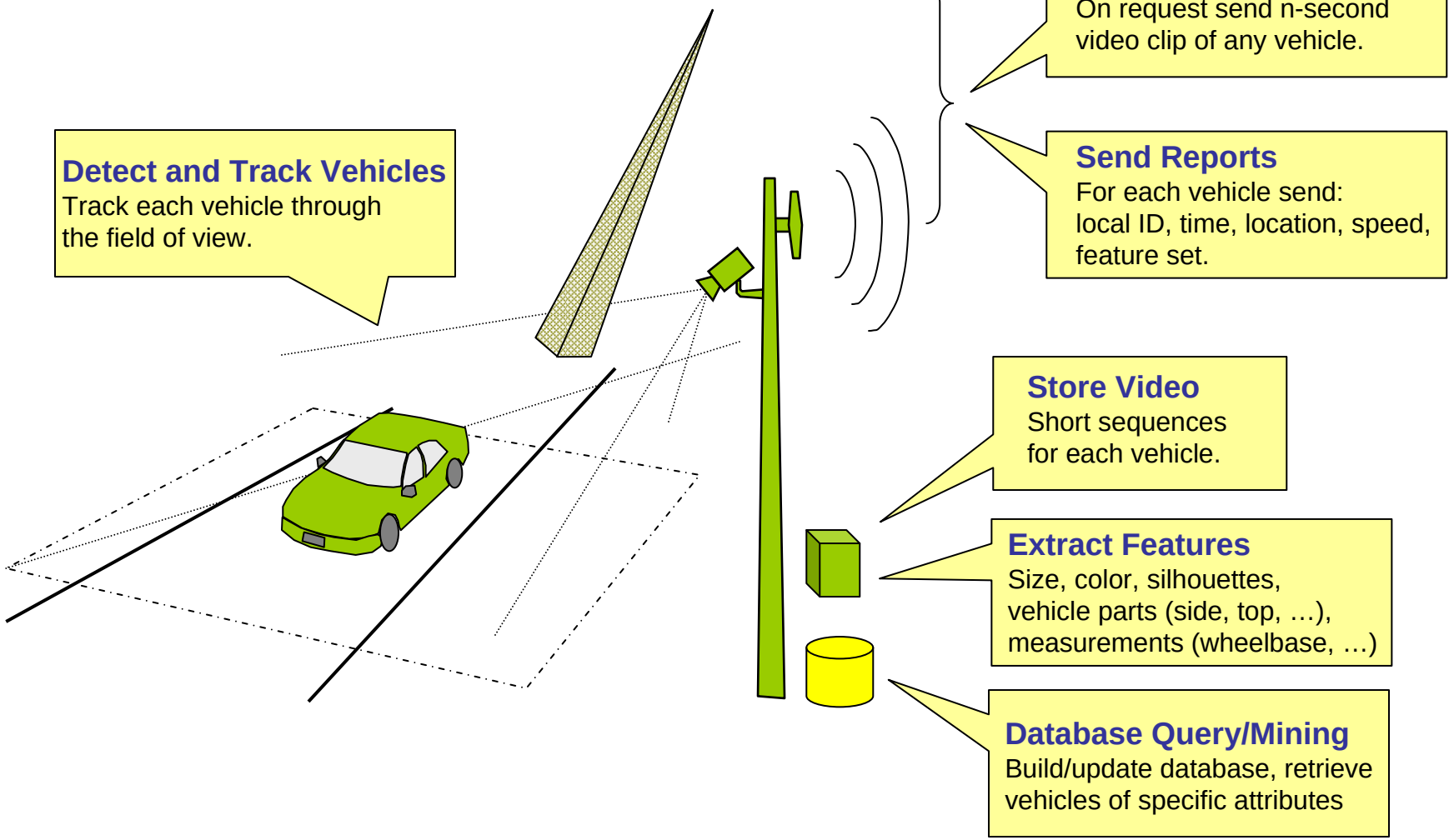
Entity Tracking

- Distributed Smart Sensor EO nodes for Wide Area Surveillance
- Vehicle signature based tracking
- Matching people to HUMINT descriptions
- Integrated system for vehicle tracking and forensic analysis combining multiple sensors (GMTI, EO/IR, IMINT and HUMINT)

Entity Tracking

- **Distributed air-ground collaborative vehicle & people association and data mining system:**
  - **Provide persistent situational awareness of an extended area.**
  - **Provides rapid and reliable sensing and response in the tactical environment.**
- **Key Innovations**
  - **Smart Sensor Processor for Moving & Stationary Cameras**
  - **Cross-Sensor Cueing and Vehicle Association across disparate pose**
  - **Multi-Sensor Multi-Hypothesis Track Fusion and Large Area Data Association**
  - **Classification, Querying, Mining & Database Functions**
  - **Distributed Scalable Processing Architecture and System**
  - **Large-area Common Operating Picture**

Entity Tracking



Entity Tracking

- **MHF: Multiple Hypothesis Fusion with map and road network information**
  - **Manage and combine multiple local target tracks to form multiple globally consistent tracks with map & road network.**
  - **Combine multi-camera based video tracks with GMTI**
  - **Essential for long range and wide area automatic multiple target tracking.**

Images to Network Understanding

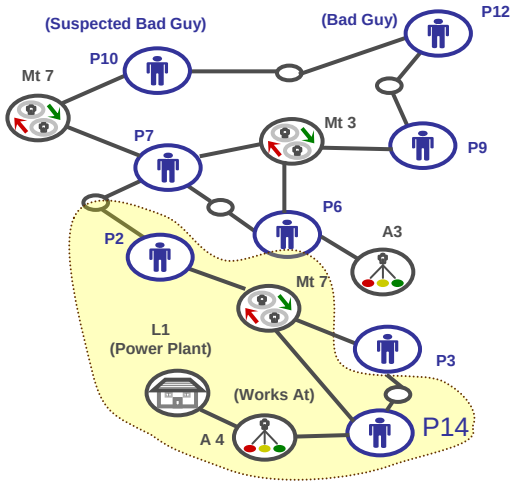
- Dynamic face recognition watch list
  - Best shot Facial Recognition from video
- Detect suspicious aggregate population or individual activity and provide warnings
- Detect human figures from surveillance video and perform human activity statistical analysis to detect unusual crowd activity
- SNA for terrorist/insurgent networks, identify key individuals in the organization, and analyze the organizational dynamics based on Video-INT

SOA / Local Tactical Network and DCGS-MC

- Service Oriented Architecture
  - Service Oriented Architecture (SOA) for LTSN, based on the DCGS Integration Backbone (DIB)
  - Disadvantaged User Interface
  - Create Software developers toolkit for interfacing to the SOA software framework
  - Sensor visibility
- Link to DCGS-MC
  - Adapt to small tactical unit environments with metadata catalogs at three simulated PoR sensor interfaces

COMINT to Network Understanding

- Detect aggregates from COMINT datasets
- Analyze and propagate suspicion at the entity and aggregate level
- Analyze aggregate evolution over time
- Develop pattern analysis and event correlation tool

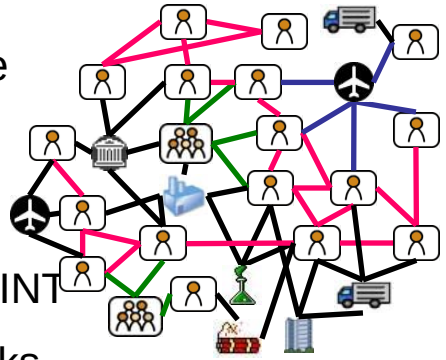


COMINT to Network Understanding

- Detect Patterns in the Data
  - Find threatening activity hidden in the benign
- Address Information Overload
  - Almost all activity is benign
  - Faint signal in lots of noise
- Operate when ground truth is unavailable
  - Incomplete and inaccurate evidence
  - Lack of observability
- Cannot assume A Priori Knowledge

Warfighter Alerts

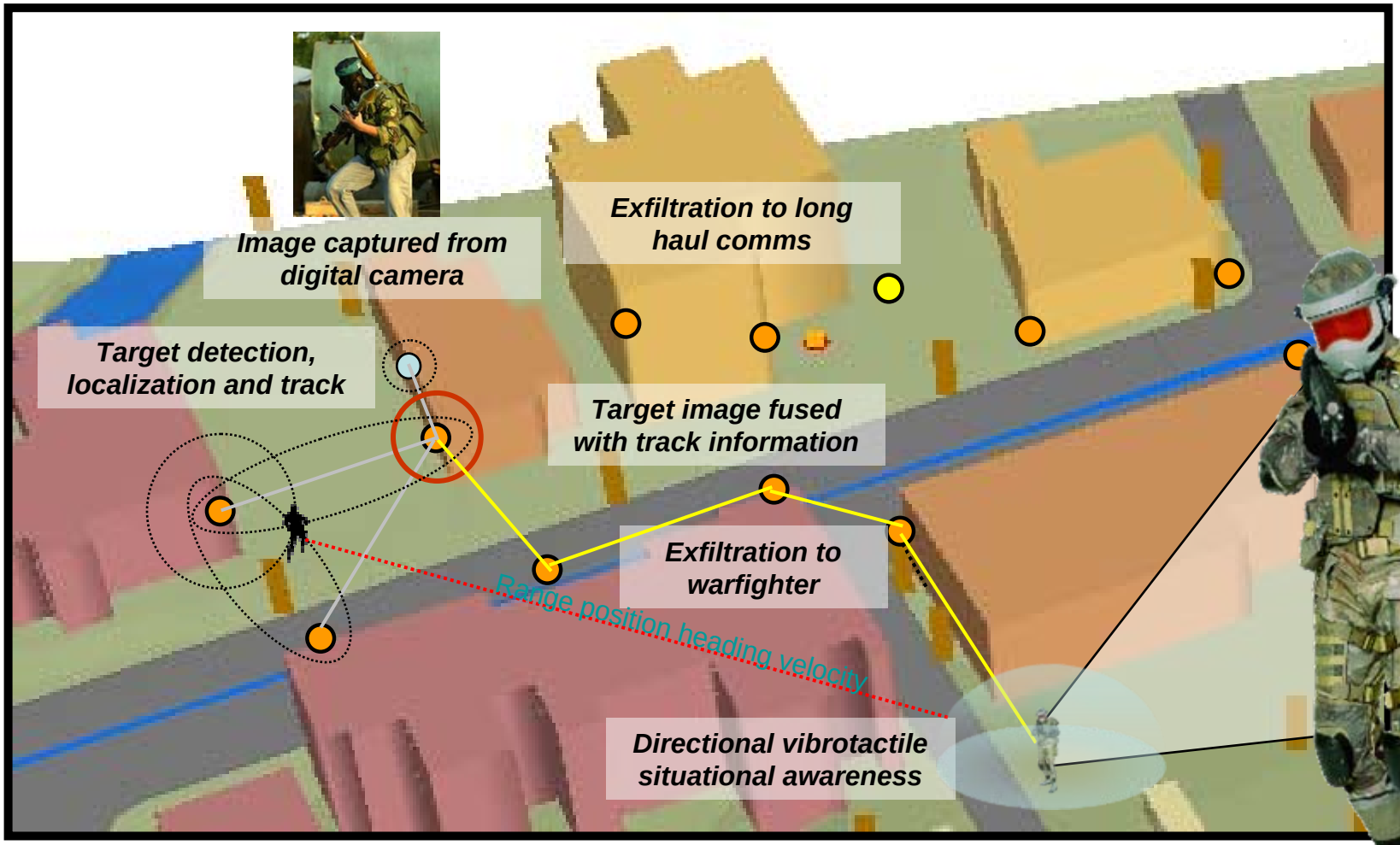
- Multi-INT Fusion for Detection of Enemy Activities and Threat Networks (Probabilistic Approach)
  - Sensors: Radar GMTI, EO/IR Video, SIGINT, Wide Area EO, SAR, HSI Imagery, Lidar Scans, HUMINT
- Geospatial-temporal Pattern Analysis software system to detect and alert threat activities
  - Exploit multi-INT, kinematic, geospatial and transactional data
- Server-side network analysis technology to:
  - Fuse acquired network information with prior knowledge
  - Characterize networks by type and properties
  - Assess entities and networks
  - Recommend courses of action to collect clarifying HUMINT
  - Recommend courses of action to disrupt enemy networks



Mission Aware Sensor Field

- Real-time, context dependant situational awareness for the warfighter
- Mission-based I&W to warfighter
  - Investigate methodology for delivery
    - Vibro-tactile, speech, etc
  - Create methods for push of I&W
- CLENS as possible demo sensor

Mission Aware Sensor Field



System Concept: Convert intel data collection tools ➔realtime tactical asset

Enabling Sensor Swarms

- Optimization algorithms and collaborative control protocols for allocation of tasks to UAVs
- Various Airborne platforms with various sensor modalities: lidar, near infra-red, or thermal infra-red
- Geographically Distributed Users with different priority rights on different platforms
- Allow for sensor fusion for multiple intelligence sources (Multi-INT)

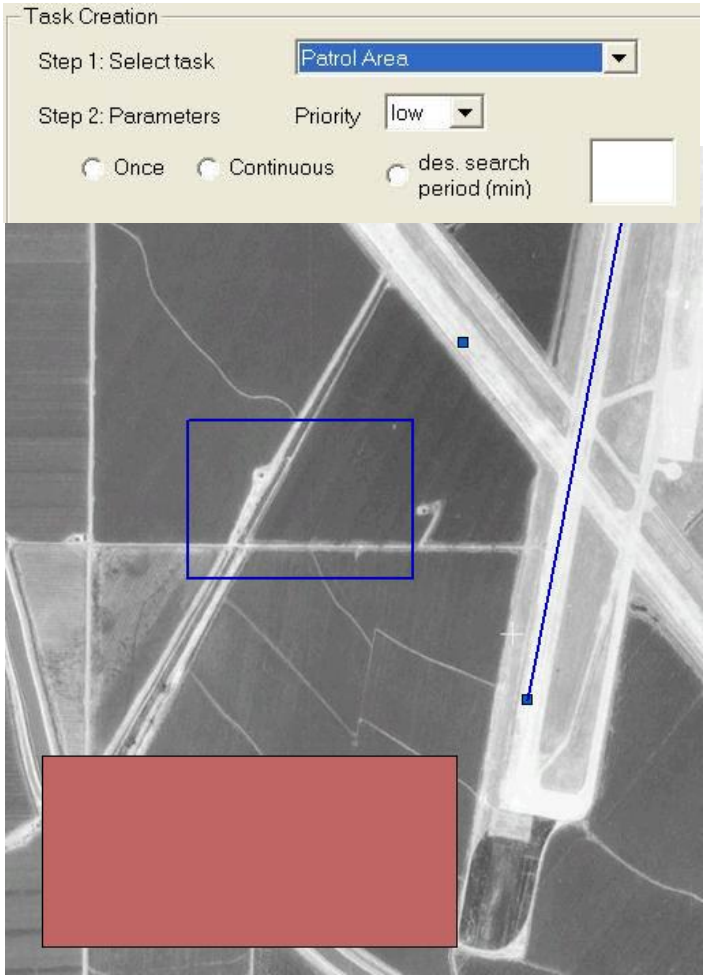
Enabling Sensor Swarms

- User defines the mission
- UAV's define tasks and sub-tasks
- Philosophy

*"The user specifies **what** he or she would like accomplished.*

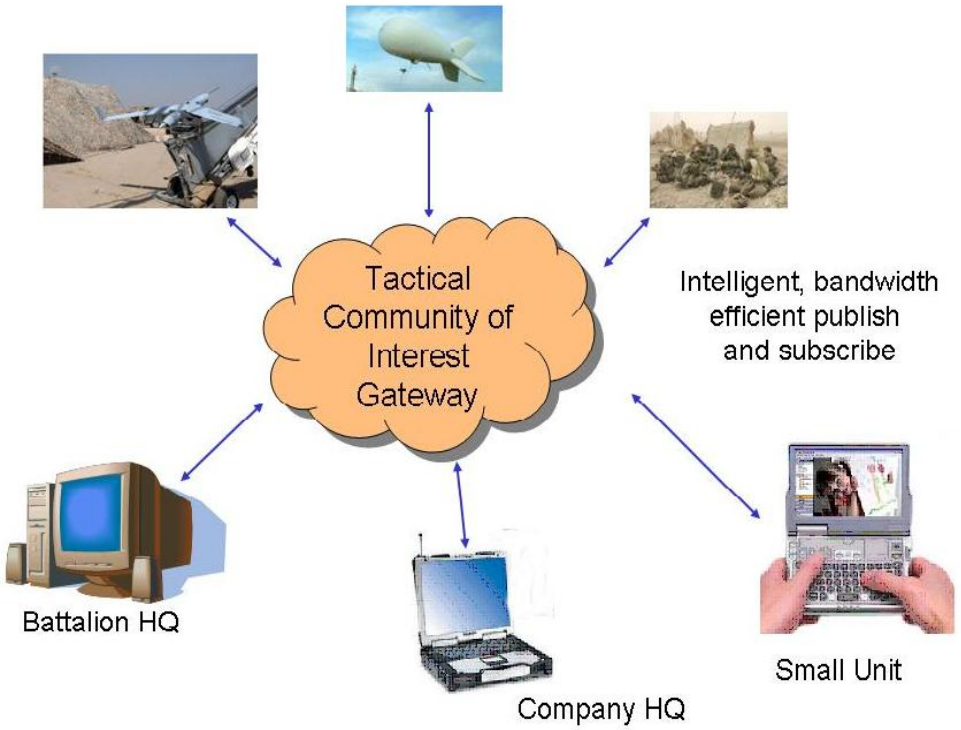
*The system decides **how** to do so efficiently."*

•Previous work has successfully flown four vehicles simultaneously.



Distributed Knowledge and Knowledge Needs

- Tactical Intelligence Ontology Development
  - Ontology for All levels of Command
  - Who needs what data based on what is available and when
    - Smart multicast support for dissemination to maximize bandwidth usage
    - Smart subscription
- Proof of Concept Tactical Intelligence Community Of Interest



Interface to Warfighter

- HUMINT via Spoken Interface, Alerting Agents
- Structuring of HUMINT Reports
- Develop System Architecture, Interaction Paradigms, User Interface Mock-ups and specs for Tactical Users
- Cognitive Task Analysis, Workflows